Community Development Patterns and Energy Conservation Study

Final Report

Ministry of
Municipal Affairs
and Housing

Ontario

COMMUNITY DEVELOPMENT PATTERNS AND ENERGY CONSERVATION STUDY

FINAL REPORT

August 1982

Woods Gordon

Management Consultants

and

THE STARR GROUP
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EXECUTIVE SUMMARY

The potential for energy conservation through innovative community planning has received increasing attention in recent years. Community planners have recognized the importance of energy conservation but have lacked appropriate methodologies, tools and techniques for incorporating energy utilization considerations in community development decisions. This Study is an attempt to address these issues, recognizing that energy consumption is just one of many planning considerations (e.g. social, economic, built form) which must be addressed. More specifically, the Objectives of the Study have been:

1. Determine potential planning directions to develop more energy efficient community settlement patterns;
2. Quantify the relationship between land use and energy consumption; and
3. Measure the impacts of:
    - o maintaining the status quo in planning practices
    - o adopting new directions in planning consistent with energy conservation objectives.

Key Findings

- o Community planning can be the instrument by which significant energy conservation can be achieved through the development of more energy efficient settlement patterns in Ontario cities.
- o When the methodology proposed in this study is applied to the Cities of London and Peterborough, the result is the potential for an estimated 4% decline in total energy consumption by those cities by the year 2001, assuming that long-term Official Plan policies are modified to reflect the energy conservation approaches identified in this report (see Figure ES-1).
- o It is estimated that the direct energy savings, in 1982 dollars, in London could total almost $25 million per year and in Peterborough the savings could be $4 million per year beyond any energy savings realizeable through technological advances (see Figure ES-2).

- o Transportation energy use in particular would be reduced in both cities and would be associated with noticeable improvements in the energy consumption associated with residential, commercial and industrial land use activities.
- o The results achievable in London and Peterborough if matched by similar initiatives and results in other communities over a number of years would result in substantial energy savings for Ontario.

The Methodology

- o The methodology developed in this study has the following components:

  a) Identification of a community's existing settlement pattern with respect to its Intensity of Land Use and its Distribution of Land Use.

  b) Development of a Land Use/Energy Profile and the Quantification of Land Use/Energy Relationships* which can be used to assess a community's current and official plan projected settlement patterns.

  c) Development and Utilization of an Evaluation Matrix to test the feasibility and practicality of potentially energy conserving planning approaches.

The application of this methodology allows community planners to determine the energy savings which could be realized through alternative community development. It also allows for the integration of energy conservation considerations with the social, environmental, land use and other concerns which are fundamental to sound community planning.

* This aspect of the methodology builds on the research of Owen Carroll at the Brookhaven National Laboratory.

Conclusions: Where Do We Go From Here?

This Study has taken a first step in the development of an approach to energy conservation in Ontario cities through community planning. An approach to community planning and development which recognizes energy efficiency holds many advantages:

- It is consistent with the economic realities facing Ontario.
- It can result in potentially significant savings in energy use.
- It can lead to multiplier savings in energy consumption throughout the community.
- It can provide a sound basis for decisions facing planners now and in the future.

The simple techniques outlined in this Report with respect to energy/land use analysis, evaluation and planning show promise. They can be developed and applied with readily available data, refined and customized through the work of local community planners and implemented with confidence. Although very little meaningful research has been conducted into these broader approaches, the results of our Study demonstrate the potential for positive results.

The questions which remain are many. Further research into costs and benefits (particularly social costs) associated with energy conserving planning approaches is a key. Refinement of energy consumption indices and appropriate land use variables would be most useful particularly through further comparison with actual consumption data. Establishing land use intensity/distribution patterns for a wide range of Ontario communities in order to allow comparison would be extremely helpful. The effect of urban size and form must be clarified. Refinement of transportation/land use impacts could be accomplished through the development and testing of appropriate gravity models.

Handbook materials and other information should be developed for distribution around the Province. Greater understanding of the fundamental relationships between intensity of land use, distribution of land use, cost of services and energy consumption would be of tremendous value. Further innovative design work on broad urban settlement forms and energy consumption would contribute further.

Planning approaches to the future development and redevelopment of communities across Ontario will continue to evolve. The ideas presented in this Study and the further areas of research and development noted above could represent an important step in this evolution. We look forward to being part of this most interesting stage in the evolution of planning thought in Ontario.

FIGURE ES-1

SUMMARY OF DIRECT ENERGY SAVINGS

ENERGY EXPRESSED AS KWH X 10^7 PER YEAR

	London - 2001		Peterborough - 2001	
	Trends Scenario (1)	Conservation Scenario (2)	Trends Scenario (1)	Conservation Scenario (2)
Residential	458.4	448.9	114.0	109.8
Retail	57.9	57.9	14.5	14.5
Service *	344.3	331.4	38.0	37.5
Industrial	564.4	526.4	105.5	100.2
Transportation (Work Trips Only)	118.9	108.7	11.4	10.4
Total	1,543.9	1,473.3	283.4	272.4

(1) Assumes Official Plan Policies and Land Use Designations are realized.
(2) Assumes energy conserving planning approaches are adopted.

Source: Woods Gordon, Enerplan

FIGURE ES-2

SUMMARY OF DIRECT ENERGY SAVINGS

ENERGY EXPRESSED AS MILLIONS OF DOLLARS PER YEAR IN 1982 PRICES (1)

	London - 2001		Peterborough - 2001	
	Trends Scenario	Conservation Scenario	Trends Scenario	Conservation Scenario
Residential	$160.4	$157.1	$39.9	$38.4
Retail	20.3	20.3	5.1	5.1
Service	120.5	116.0	13.3	13.1
Industrial	197.5	184.2	36.9	35.1
Transportation (Work Trips Only)	47.6	43.5	4.6	4.2
Total	$546.3	$521.1	$99.8	$95.9

(1) For Land Use an average cost of 3.5 cents per KWH was used. This is based on an average cost of all energy sources utilized in land uses. It includes consideration of lower rates for bulk users of electricity and natural gas. For Transportation an average cost of 4.0 cents per KWH was used. This is based on gasoline costing 39 cents per litre.

Source: Woods Gordon, Enerplan

1. INTRODUCTION

Development patterns in Ontario's communities represent a physical expression of evolving values and attitudes and a response to changing economic, social and demographic conditions. Traditionally, community planning practices have attempted to capture these values and attitudes to order and manage development accordingly.

Over time, the influence of these values and attitudes (and hence planning practices) on community development patterns is readily apparent. One has to look no further than the following quote to recognize the relationship between these values and their eventual physical translation:

> "The provision of small houses on unoccupied land is a suggestion which is so often encountered that we cannot entirely ignore it. If such a project meets existing needs, it has undoubted advantages... Perhaps the greatest advantage, apart from the possibility of lower land cost, is that they supply exactly what most of the people visualize as a home - a small, self- contained dwelling with its own little garden in a pleasant and healthy neighbourhood."

Source: "Lieutenant-Governor's Committee on Housing Conditions in the City of Toronto", Queen's Park Printers, 1934. P. 114.

Such attitudes eventually gave rise to massive outward expansion of urban areas in Ontario, aided by technological innovation and supported by public expenditures on transportation and service networks.

Suburbanization, of course, is but one aspect of community development which has been supported by traditional planning principles at one time common throughout Ontario. Other examples would include separation of land uses, concentration of commercial office and institutional development within the Downtown Core, discouragement of

residential development within the Core, demolition and redevelopment of aging inner city neighbourhoods, ongoing expansion of road systems to accommodate the journey to work, support for suburban shopping centre development, and so on.

But attitudes and values have evolved, accompanied by dramatic changes in economic conditions. One by one, traditional planning practices have been challenged and new principles and approaches identified. Renewed interest in the future of Ontario's downtowns has led to a growing movement toward downtown revitalization and preservation of inner city neighbourhoods. Innovative mixed-use forms of development are becoming more popular as communities witness the exciting results of a more integrated urban fabric. Deconcentration of commercial office and institutional development is presenting advantages to some of Ontario's larger communities by easing traffic congestion and reducing redevelopment pressures in the Core.

Clearly, these emerging ideas are bringing new directions to the long-term planning and development of communities across Ontario. Yet, there remains undefined an overall approach to guiding the urban settlement pattern of the future. A clear framework is needed to support the efforts of community planners throughout the Province. This framework must lay the foundation for the application of planning principles which reflect emerging values and coincide with anticipated economic conditions.

Energy efficiency has been suggested as the basis for such a framework. Through supporting community development patterns which conserve energy, it may be possible to define a basic approach to community planning and development decision-making. This approach would

not only coincide with a great many of the newer directions emerging in community planning in Ontario, but would reflect the economic realities facing this Province for years to come.

The consumption of energy within a community is linked strongly to many aspects of urban form. Land use densities; the role, strength, size and location of the core area; locations and densities of major residential areas; road and highway patterns; the location of major employers or employment centres; the location of major commercial/ retail developments; the location of other major traffic generators; the relationship of major developments to traffic patterns; the transportation relationship among the various uses; the size and scale of the community - all contribute in various ways to the level of energy consumed in the community. By organizing land uses and infrastructure to conserve energy, it may be possible to establish a basic framework for guiding community planning and development decision-making over the next twenty years.

In order to develop energy efficient planning practices this approach, therefore, an understanding of the relationship between community development patterns and energy consumption is critical.

While reorganization of land uses may give rise to energy efficiency in theory, the reality in Ontario is that urban settlement patterns already have largely been set in place, shaped by the initial concentrated form of late nineteenth and early twentieth century development and the subsequent suburbanization of the post-war period. Declining population growth and reduced rates of economic expansion point to relatively modest additions to urban areas over the next twenty years. Many potential energy-saving planning techniques simply have limited application in such an environment.

In order to implement energy efficient planning practices an understanding of the practicality and feasibility of various potential planning approaches for energy efficiency available to a given community is important.

Finally, planners must be able to determine the effects on the community of an energy efficient planning and development approach. The magnitude of energy savings must be measured, and costs incurred understood. Any associated economic and social costs and benefits also must be identified.

In order to determine the results of energy efficient planning practices an understanding of the potential energy savings to be realized and associated costs and benefits incurred, is critical.

This Study has been undertaken to explore the development of an energy efficient approach to community planning and decision-making in Ontario. If successful, these efforts can help set in place a clearly articulated framework for the long-term development of communities in Ontario.

This work is very much a pioneering effort. Most of the research carried out to date in North America on planning and energy conservation has pertained to site specific and technical applications of energy conservation measures. The focus of this Study is on a much broader scale and a much longer term. The results can have far-reaching consequences for the ultimate form and organization of urban settlements across Ontario.

In keeping with the discussion presented above, three key objectives were defined for the Study:

1. To determine potential planning directions to develop more energy efficient community settlement patterns;

2. To quantify the relationship between land use and energy consumption;

3. To measure the impacts of:

   - maintaining the status quo in planning practices

   - adopting new directions in planning consistent with energy conservation objectives.

These objectives have been defined with the intent of providing information and methodologies useful to planners across Ontario interested in pursuing energy efficient approaches to community planning and development. Methodologies have been provided for ensuring that the approach being developed in any given community is both practical and feasible. An emphasis has been placed on quantification through use of readily available data in order to facilitate measurement of impacts.

To demonstrate clearly the applicability of the conservation approaches developed in this project, a case study approach was used. Two communities of differing scale - one of approximately 50,000 population and one of approximately 250,000 population, were selected. The intent was to study communities representative of the bulk of Ontario urban centres of each size in terms of physical form and location, population characteristics, housing mix, growth trends, economic base and planning practices. Peterborough and London were felt to reflect these criteria and, therefore, were selected.

All data and methodologies developed in the study were applied to these communities to test the applicability of the approach and to determine potential outcomes. Full co-operation from staff in both communities was received throughout.

The study progressed in several stages over a nine-month period:

- o Literature Review and Case Study Selection
- o Development Pattern/Energy Use Assessment
- o Conservation Opportunity Identification
- o Scenario Development
- o Final Report

This Report summarizes the results of our explorations into developing an energy efficient approach to the overall long-range planning of communities in Ontario. A brief discussion of energy efficient community development patterns is presented, followed by an outline of the methodology we have developed for the quantification of land use/energy relationships and examples of results in the case study communities. The methodology used to test for practicality and feasibility of potential energy conservation approaches is noted, followed by an illustration of energy efficient scenarios and the impacts on energy consumption in each case study community for the year 2001. A Technical Appendix which elaborates on the techniques and methodologies developed over the course of the Study is also provided.

This Study is only a beginning. Our research has raised many questions and opened up many areas for investigation. The final section of this Report, therefore, discusses future research which might be undertaken to further refine the concepts and methodologies developed in the Study. With support from the Ontario planning community, these efforts can initiate a major thrust toward the articulation of a fundamental approach to community planning over the next twenty years.

2. ENERGY EFFICIENT COMMUNITY DEVELOPMENT PATTERNS

2.1 Introduction

An extensive reivew of recent literature and discussions with individuals and organizations carrying out work in energy and land use planning revealed little research into the broader aspects of community development patterns and energy conservation. Most recent research pertains to site specific and technical applications of energy conservation measures. Nevertheless, through these investigations and the discussions of our Project Team, two principles fundamental to energy efficient community development patterns were identified:

- o INTENSITY OF LAND USE
- o DISTRIBUTION OF LAND USE

2.2 Intensity of Land Use

Intensity of land use relates to the density and form of urban development. Generally, greater intensification conserves energy by making urban activity and interaction more concentrated, more compact and contained within a given urban area. Increasing intensity reduces the cost of interaction, namely transportation and communication, through reducing the distance between activities. Higher densities result in economies of scale in the provision of services and yield the thresholds necessary to support public transportation. Four aspects of intensity are particularly relevant to the notion of energy efficient community development patterns - density, concentration, compactness and containment.

Density of development plays an important role in heating and cooling energy. Studies have shown that multi-unit dwellings consume about 30% less energy on a square-foot basis for heating and

cooling than single family units. This is due to a lower amount of exterior wall area, on average, per dwelling unit and economies of scale in providing heating and hot water.

Density also has a strong effect on transportation energy through its influence on mode of travel and length of trip. Transportation energy is reduced as more people make use of public transit or walk. Higher densities also give rise to shorter average trip lengths, thereby further reducing transportation energy consumption.

Public transit usage is enhanced in a higher density situation for several reasons. More trip origins and destinations per section of route mean a higher basic demand. As travel demand is able to fill a minimum number of transit vehicles, service improvement can be made, which in turn attracts greater ridership. Shorter waiting times, shorter trip lengths and more difficult parking conditions at higher density leave transit travel times more competitive with automobiles.

Concentration refers to the proportion of an urban activity that takes place in one small area relative to the entire area or region being examined. Concentration may be increased in either of two ways; either the proportion of total urban activity taking place in the smaller area increases, or the proportion of activity remains fixed while the size of the concentrated area shrinks relative to the size of the entire area being examined.

The effect of concentrated development on transportation energy is similar to the effects of higher density. Concentration results in shorter trips and greater transit use. It also generally

raises densities, thereby achieving heating and cooling efficiencies associated with higher density.

The potential for district heating, for example, is enhanced in a concentrated community. District heating is a centralized heat source with an associated distribution system serving several consumers. Via underground piping, these consumers are provided heat in the form of steam or hot water. The energy savings are realized in economies of scale or the ability to use a greater range of fuels in the central heating plant.

The concept of compactness refers to the physical shape and extent of a community. For example, a city developed in corridor fashion (e.g. along a shore line) is generally less compact than a circular city of the same area.

The shape and extent of an urban area influences the type and amount of transportation required. It affects the average distance between origins and destinations and the form of the transportation network which serves the area. A compact shape permits more direct and shorter distance trips, whereas a non-compact shape lengthens the time, distance and therefore the energy consumed in trips. Longer, less direct trips act to make public transit less attractive.

Related to compactness is the concept of containment. This refers to establishing a boundary on an urban area and restricting development outside the bounded area. The boundary often will follow the edge of the existing built-up area. This principle is designed to force more efficient use of the existing land resources of the community.

As the demand for land grows (due to growth in population, income or level of economic activity) and the supply remains fixed, the price of land increases. This price increase forces more intensive and efficient use of land, usually at higher densities. Pressures for development and redevelopment of vacant lands often increase.

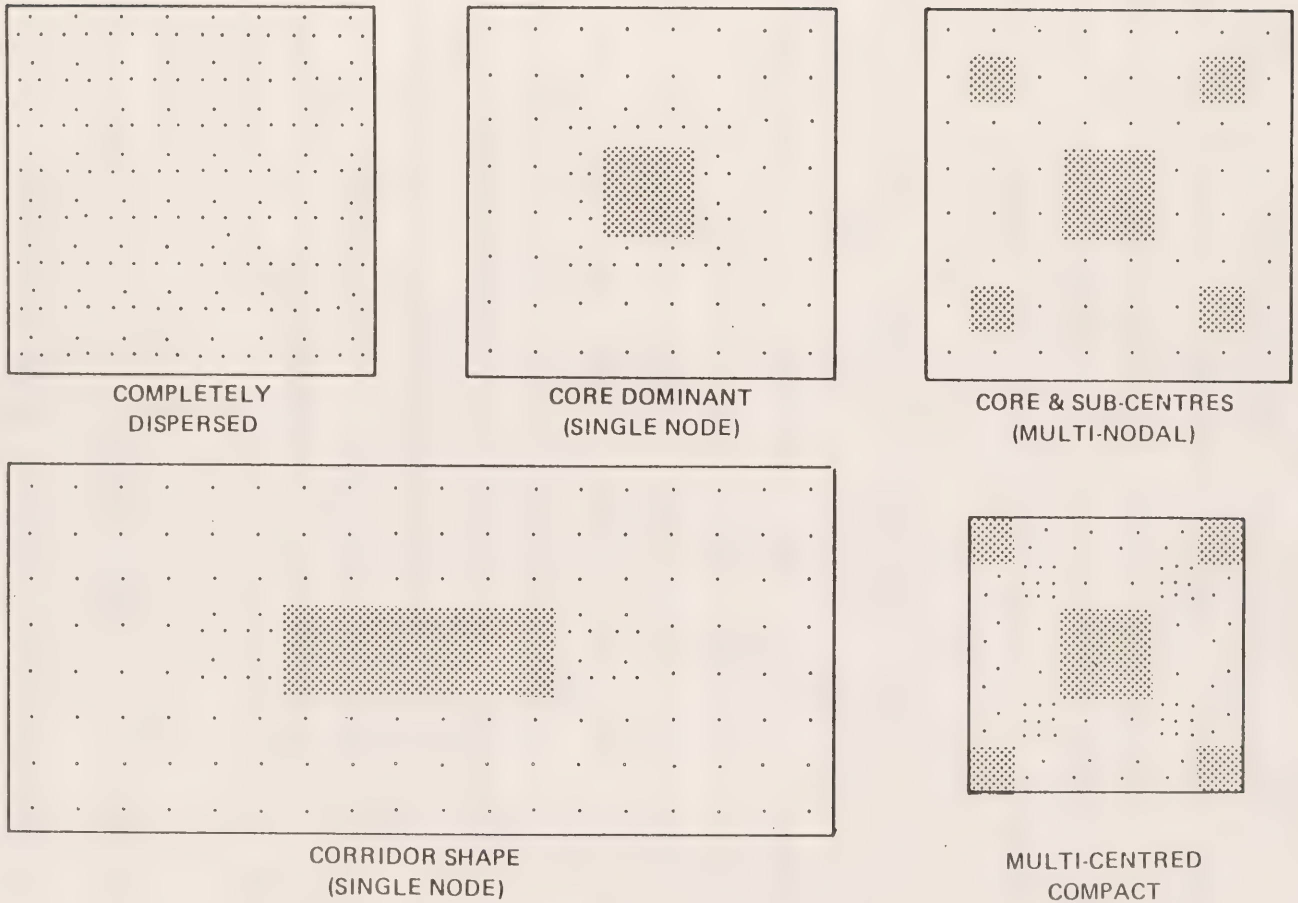
There are often political and institutional problems associated with a strict application of this principle. It has been found ineffective when applied in the past to restrict urban sprawl. It could prevent the realization of larger, more comprehensively planned developments which require the large parcels of land found at the urban fringe. A careful application of this principle, however, could contribute to more energy efficient urban form.

Intensification of land use also relates to infill and redevelopment. Infilling of new development within urban areas results in more concentrated urban form and a higher density settlement pattern. More intensive use of existing buildings through renovation at higher density and mixed use also contributes to energy savings. Infilling and redevelopment ensure existing urban services and infrastructure are highly utilized. Infill and redevelopment strategies are particularly appropriate for the mature communities found throughout Ontario and are already an important component of Ministry of Municipal Affairs and Housing programs and policies.

2.3 Distribution of Land Use

Distribution of land use relates to the spatial relationship and organization of urban development. Generally, land use

HYPOTHETICAL EXAMPLES OF URBAN FORM



SOURCE: Woods Gordon

distributions which reduce the distance between centres of human activity enhance the energy efficiency of any community.[1]

Energy efficient distribution of urban activities requires careful clustering of uses consistent with the nature of urban economic relationships. As the nature of these relationship changes, planners must respond to ensure that efficient distribution is maintained.[2] Greater planning effort is required to achieve an energy efficient distribution of land uses than to increase the intensity of land uses, as there is less flexibility in matching economic relations. Associated benefits to an energy efficient distribution of land uses can include the reduction of congestion, environmental and social costs often associated with more traditional forms of land use organization.

The distribution of land uses in any community can generally be classified as dispersed, which tends to discourage energy efficiency, or nodal, which tends to promote energy efficiency. The most traditional form of nodal development, of course, is the single node of the central business district, surrounded by development at densities which decline with increasing distance from the city centre.

Research carried out by Brookhaven Laboratories in the United States has led to the conclusion that development of a series of strategically located nodes, or sub-centres, of medium density mixed use

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1 Except in cases of spatial organization which cause extreme traffic congestion, thereby raising fuel consumption.

2 An example of this is the change which has occurred in industrial shipping since 1945 as a greater proportion of freight moves by road rather than by rail. The result of this has been a higher demand for industrial land with good road access. The planning response has been to promote industrial development adjacent to freeways or major highways and the pursuit in the 1970's of relocating of rail lines out of centre city areas.

tends to be the distribution of land uses most conducive to community energy efficiency. The principle here is to encourage the formation of several "self-contained" centres combining commercial, retail, institutional, residential and other compatible uses.[1] "Self-contained" indicates that these centres would contain higher-order commercial, retail and leisure activities in order to function as "mini-downtowns". The sub-centres can act as nodes for public transit. The use of suburban malls as timed transfer centres, for example, has worked well in Edmonton.

Sub-centres provide higher-order employment[2] at locations outside the central business district, thereby reducing the total distance travelled for work trips in the community as a whole. Sub-centre development also reduces total building energy use by providing opportunities for increased density and mixed use structures.

Corridor or radial development distributes urban activity along linear transportation corridors and can lead to a strong degree of community energy efficiency. Higher than average levels of transit service can be provided in support of this form of urban settlement. Land adjacent to the corridors would tend to become more highly valued and more intensively used. Higher densities would be encouraged along

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1 Industrial uses can also be compatible provided such potential problems as noise, waste disposal, storage and shipping can be made unobtrusive by careful operating proceedures and plant design.

2 Higher-order employment refers to a hierarchy of retail and service activities. Lower-order activities are those which are found frequently in an urban area, such as variety/milk stores. Higher-order activities refer to those which need greater demand and hence greater surrounding population to survive. Examples of higher-order activities include: department stores or specialty retail shops.

these corridors, with densities decreasing with distance from the spine. Commercial and service needs would be located along the corridor, creating a "Main Street". Mixed use buildings would be encouraged and land between the corridors could be used for medium-low density residential development. This form of development in some ways would recall the older "streetcar suburbs" of the early twentieth century.

Self-contained neighbourhood or community development is a small-scale form of energy efficient land use distribution. Historically, Ontario communities have possessed strong neighbourhood identities. An emphasis on decentralization of employment and services to this neighbourhood would have significant energy implications.

Travel distance would be reduced. Smaller scale mixed use structures would form part of an integrated neighbourhood. The corridor concept can be employed at the neighbourhood level to provide small-scale concentrations of development.

The mixed use building is perhaps the ultimate expression of an energy efficient distribution of land use. However, the location of residences, retail establishments and place of employment even at one site (as well as just one building) severely reduces overall transportation requirements for many individuals. A variety of uses at one site means that trip origin and destination times are spread over a twenty-four hour period. This reduces the under-utilization of transit vehicles in off-peak periods and raises overall energy efficiency.

Our review did not extend to technological and engineering advances or predictions of changes in human behaviour patterns. Ongoing improvements and changes made in these areas will continue to contribute to increased energy efficiency in any community

over time. For example, factors such as vehicle energy efficiency and mode of travel have a strong impact on transportation energy consumption. For the purposes of this Study, such factors were held constant in order to isolate the potential effects of more energy efficient community development patterns.

3. QUANTIFICATION OF LAND USE/ENERGY RELATIONSHIPS

3.1 Intensity/Distribution Matrix

Given the findings outlined in the previous Chapter, the first stage of analysis for any community adopting an energy efficient approach to planning development must be a determination of the level of intensity and form of distribution of existing development patterns. We have developed a matrix which can be used for this purpose (see Figure 1). Comparison of the present development pattern of the community to more energy efficient forms would enable selection of a target position on the matrix which would appear feasible, given the current status and the potential for change. In this way a basic direction for community planning efforts could be determined by planners and others.

The matrix is comprised of two indices - an index of land use intensity and an index of land use distribution. Four categories have been defined for each, in ascending order of energy efficiency. These are shown in Figure 1. Generally, the categories fall under the following definitions:

Intensity of Land Use	Distribution of Land Use
1. Low density, all sectors	1. Widely dispersed and separate
2. Low density residential, industrial and high density commercial (core and/or nodes)	2. Core predominant, some nodes
	3. Highly concentrated in core
3. Low density residential, high density industrial, high density commercial (core and/or nodes)	4. Highly decentralized and mixed
4. Medium to high density residential, high density industrial, high density commercial (core and/or nodes)	

A number of indicators can be used to measure intensity and distribution of land use and thereby position the community on the matrix. These include:

- average residential, industrial, commercial density of development;
- percentage of commercial floorspace within core and each of identified commercial nodes;
- percentage of industrial employment within core and each of identified industrial nodes;
- average time and distance of journey-to-work trips.

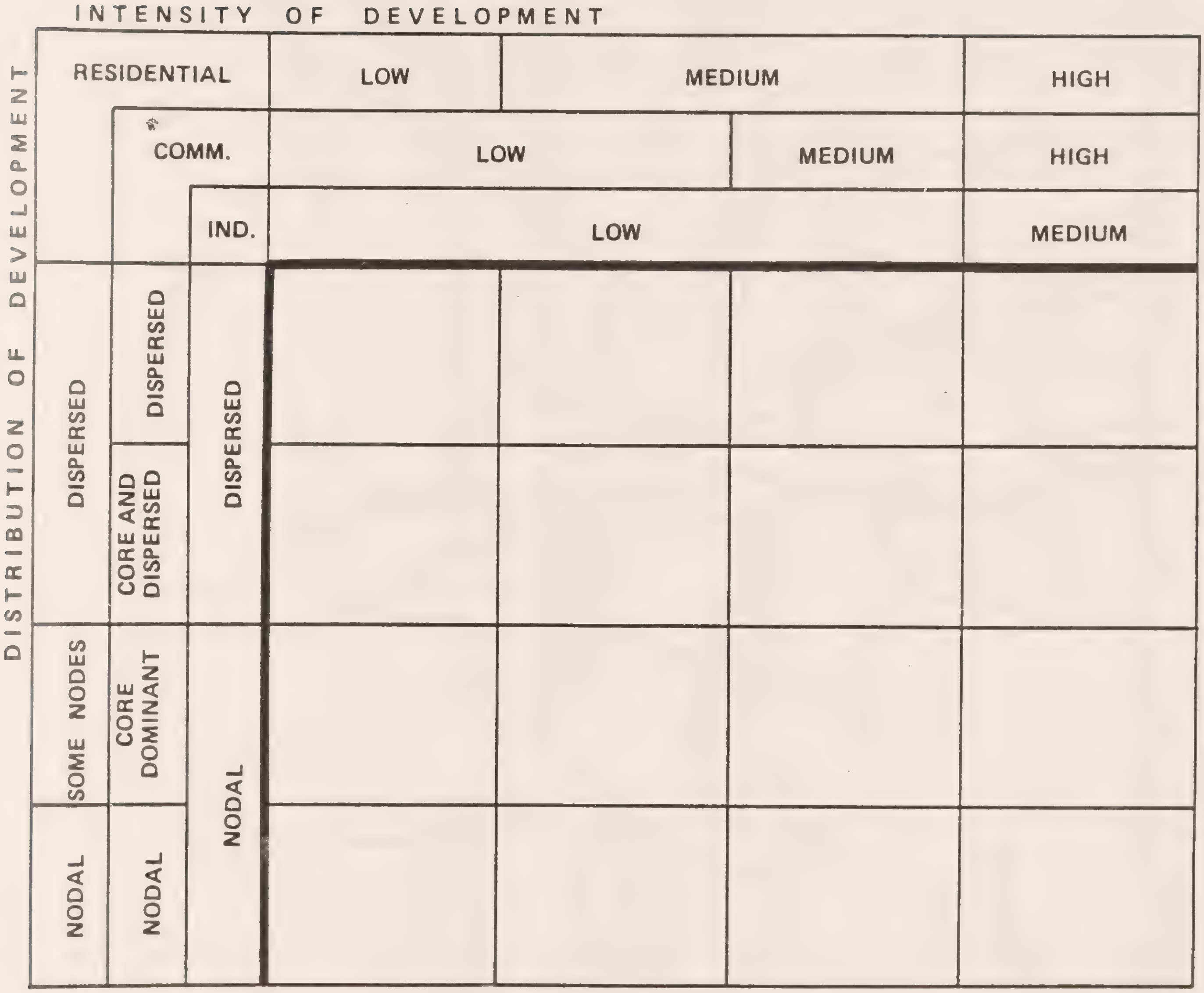
Ideally, a set of variables used to measure intensity and distribution of land use in greater detail should be developed and made available to planners. This might include comparisons among communities throughout Ontario, as well as distinctions according to size, age, etc. As time and budget available for this Study did not permit the extensive research required to develop such measures, the positioning of the case study communities on the matrix was derived through a brief analysis of the variables noted above and judgements made by the Project Team. The determination of more detailed measures of this nature is a clear area for further research in the development of an energy efficient approach to community planning and development.

Figures 2-5 provide examples of the analysis carried out for the case study communities and their ultimate positions on the intensity/distribution matrix. Figures 2(a)-2(d) indicate the development patterns of major land uses in London. Through an analysis of the variables noted above and discussions with City staff and members of the Project Team, the following positions were determined for London:

Land Use Category	Intensity	Distribution
Residential	Medium	Some Nodes
Commercial	Medium	Core Dominant
Industrial	Medium	Nodal

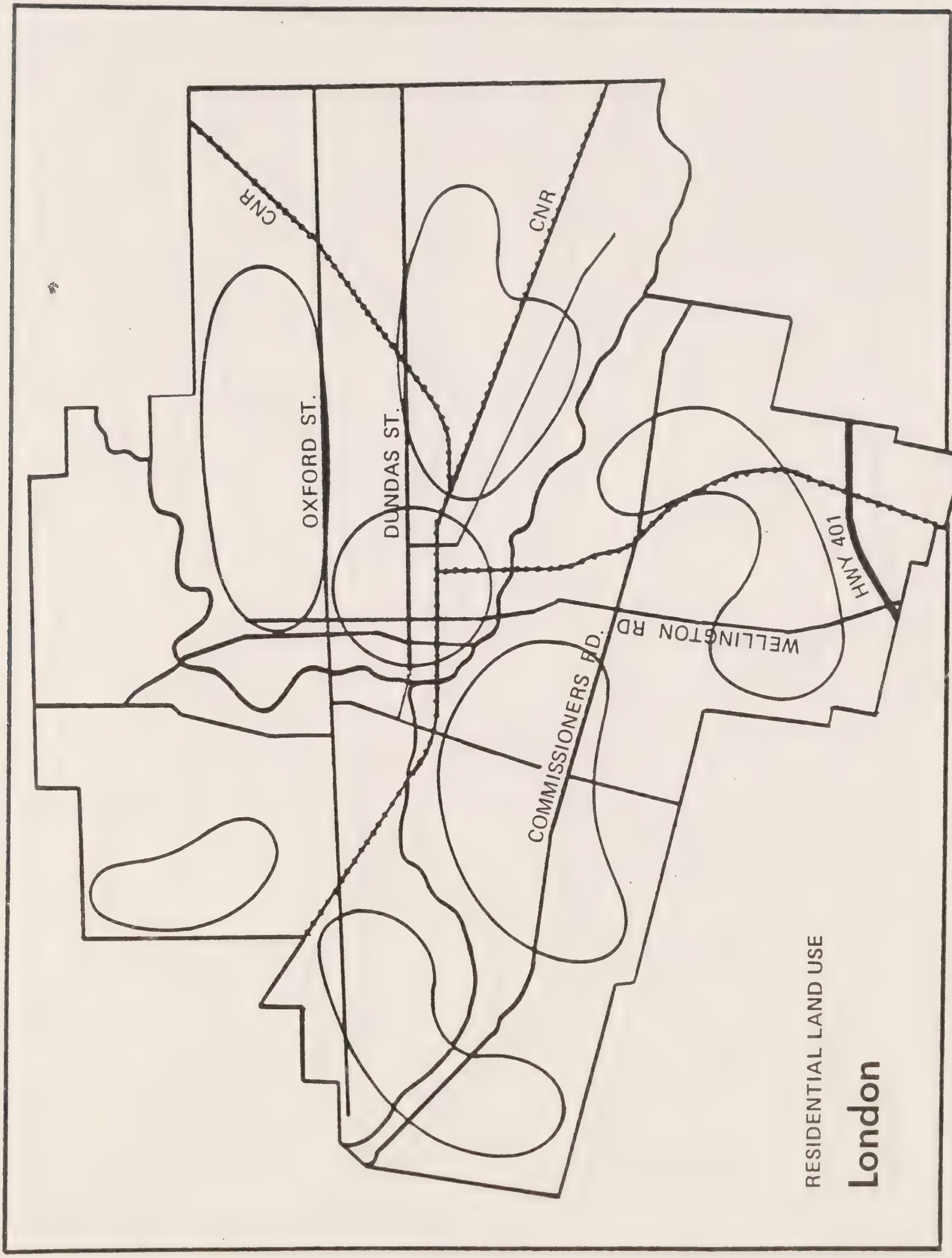
FIGURE 1

INTENSITY/DISTRIBUTION MATRIX



SOURCE: Woods Gordon, The Starr Group, Enerplan

FIGURE 2(a)

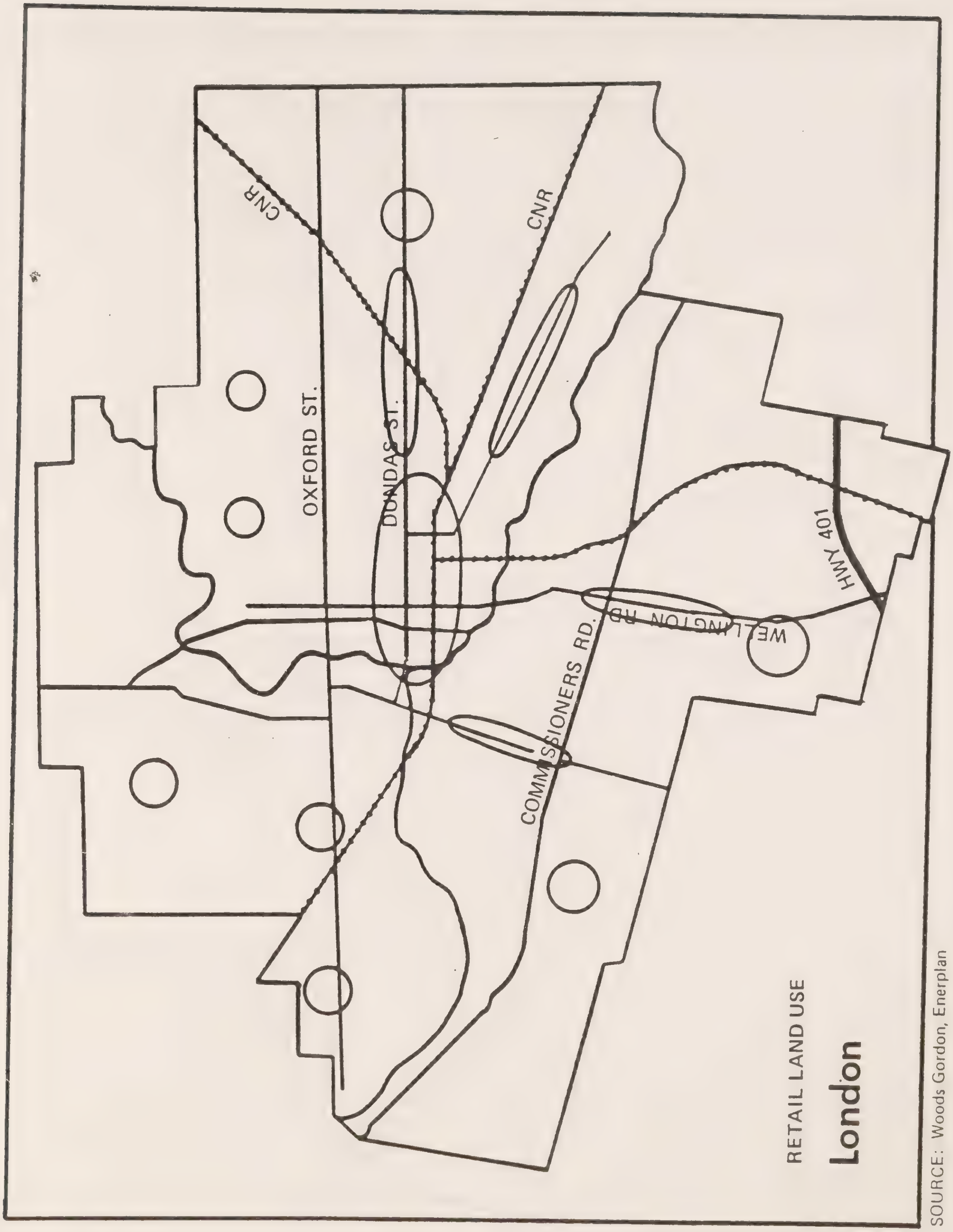


RESIDENTIAL LAND USE

London

SOURCE: Woods Gordon, Enerplan

FIGURE 2(b)

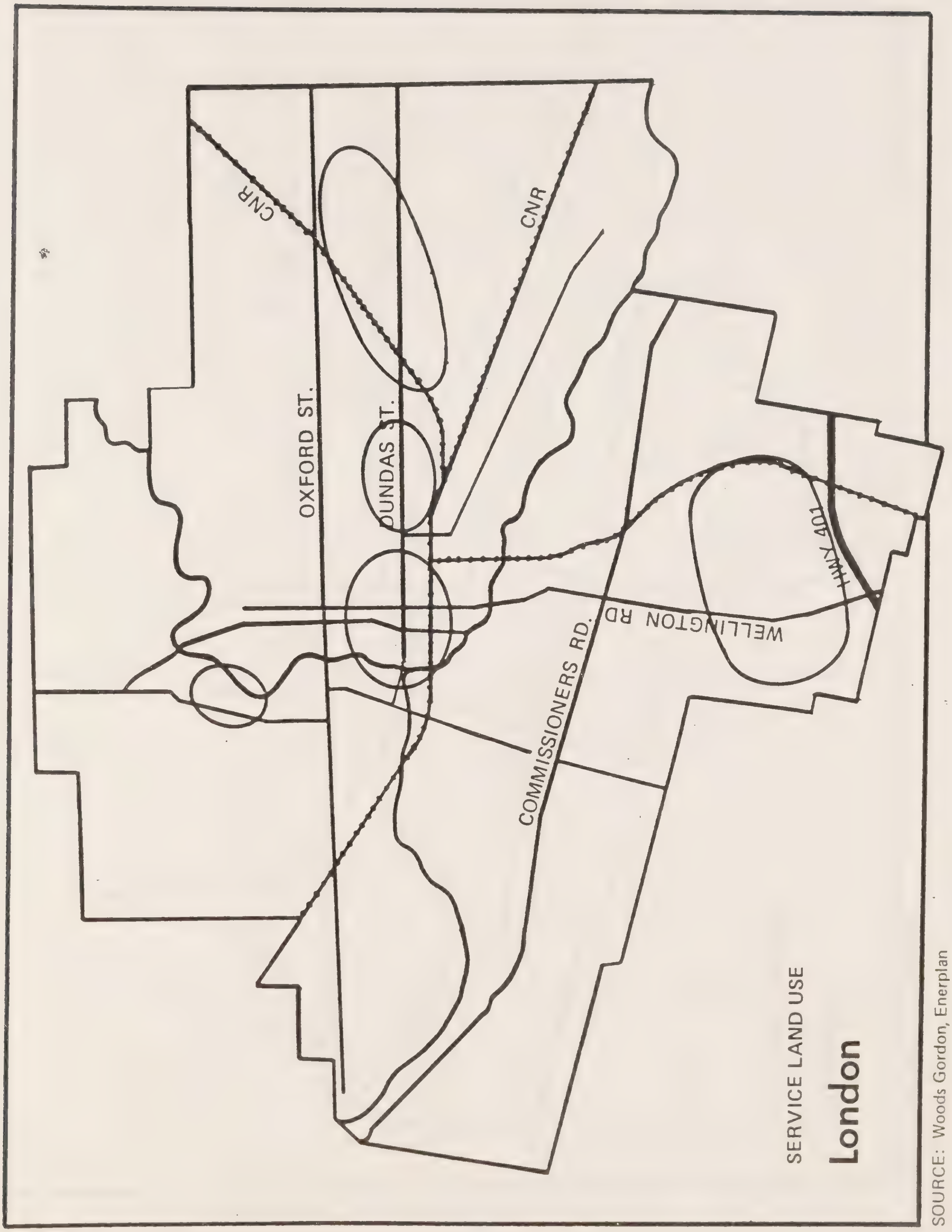


RETAIL LAND USE

London

SOURCE: Woods Gordon, Enerplan

FIGURE 2(c)

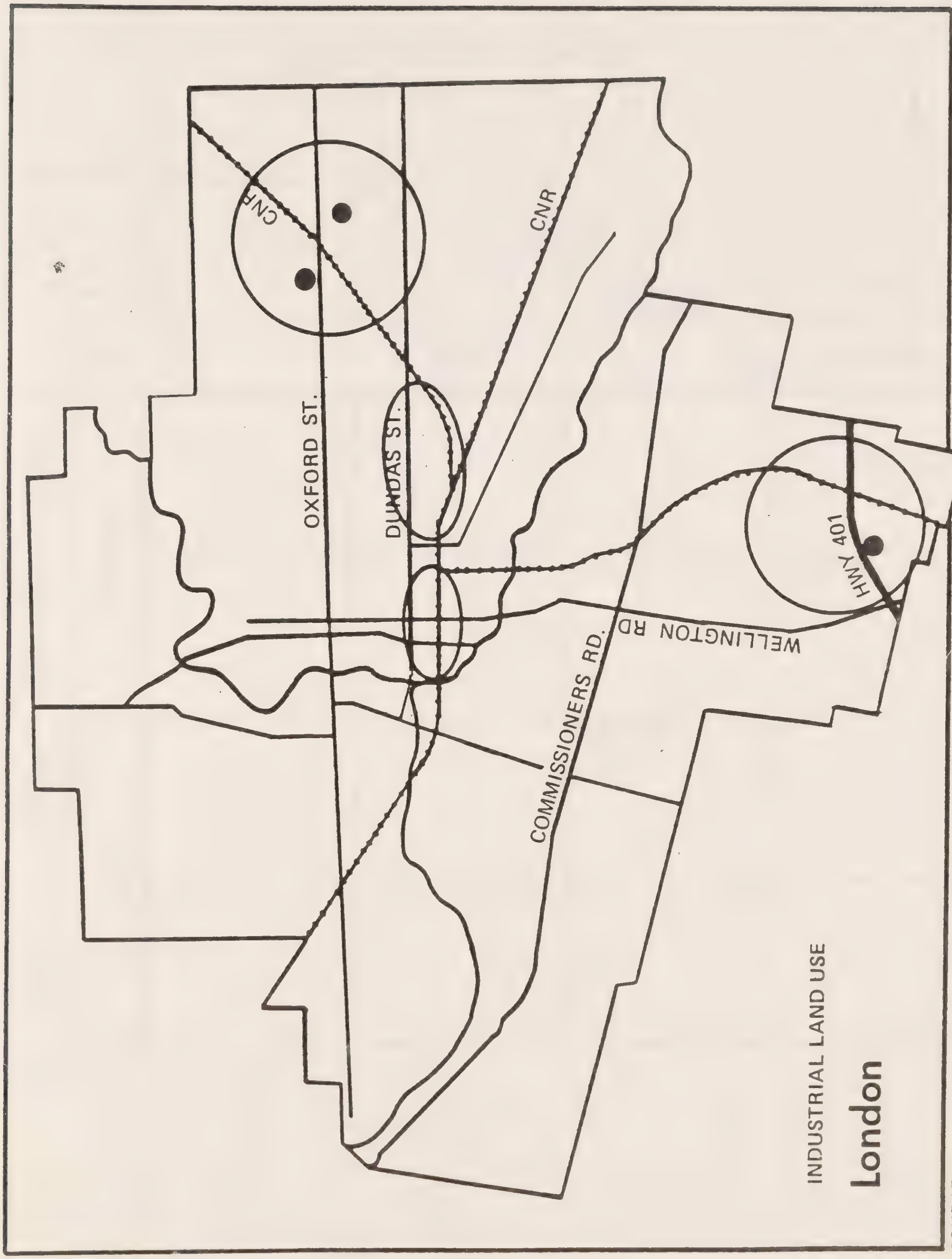


SERVICE LAND USE

London

SOURCE: Woods Gordon, Enerplan

FIGURE 2(d)



INDUSTRIAL LAND USE

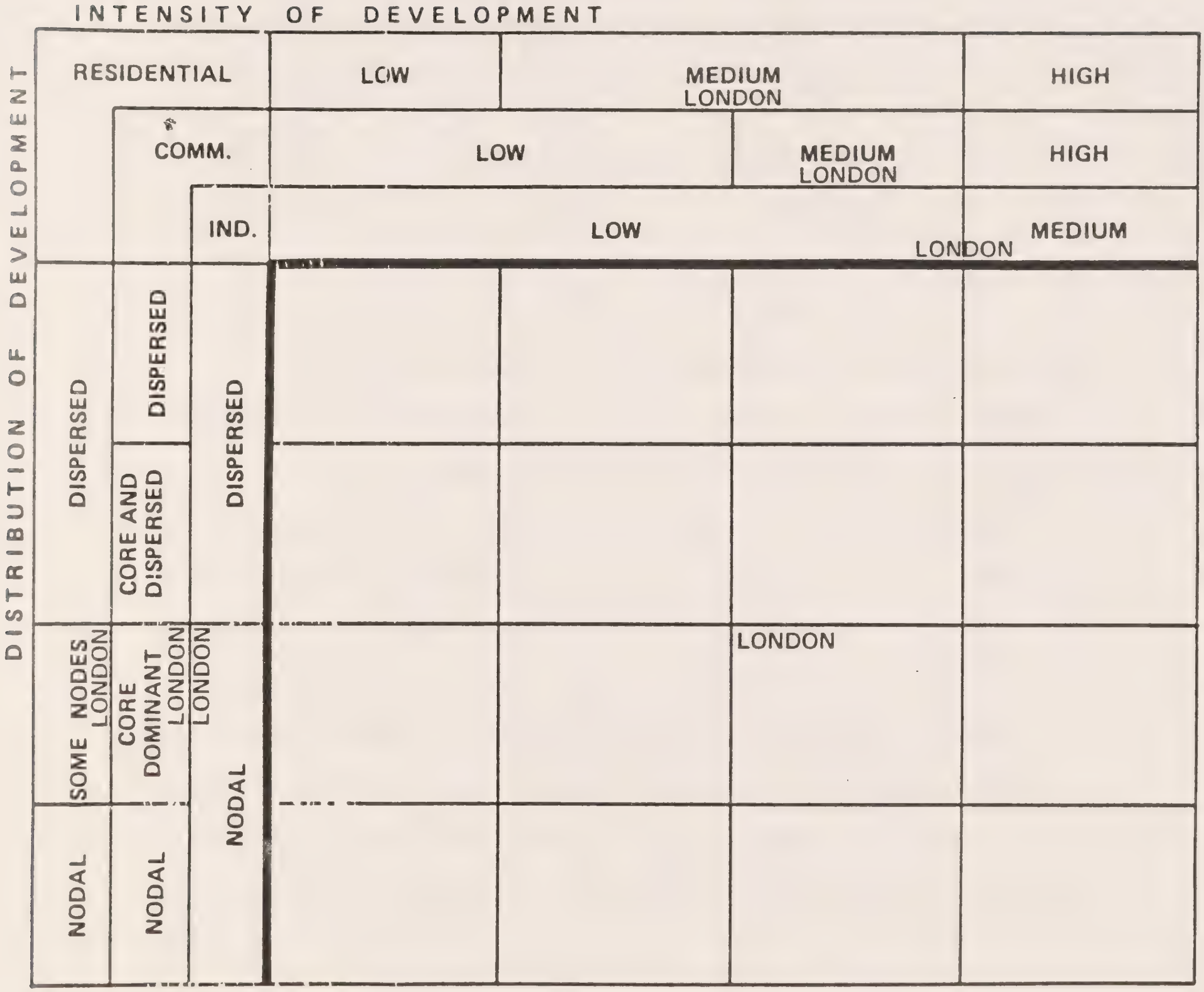
London

SOURCE: Woods Gordon, Enerplan

FIGURE 3

INTENSITY/DISTRIBUTION MATRIX

Placement of London



SOURCE: Woods Gordon

The net result of these placements left London in a relatively energy efficient area of the matrix, as shown in Figure 3.

Figures 4(a)-4(d) indicate the development patterns of major land uses in Peterborough. Through an analysis of variables and discussions with City staff and members of the Project Team, the following positions were determined for Peterborough:

Land Use Category	Intensity	Distribution
Residential	Low	Dispersed
Commercial	Low	Core and Dispersed
Industrial	Low	Nodal

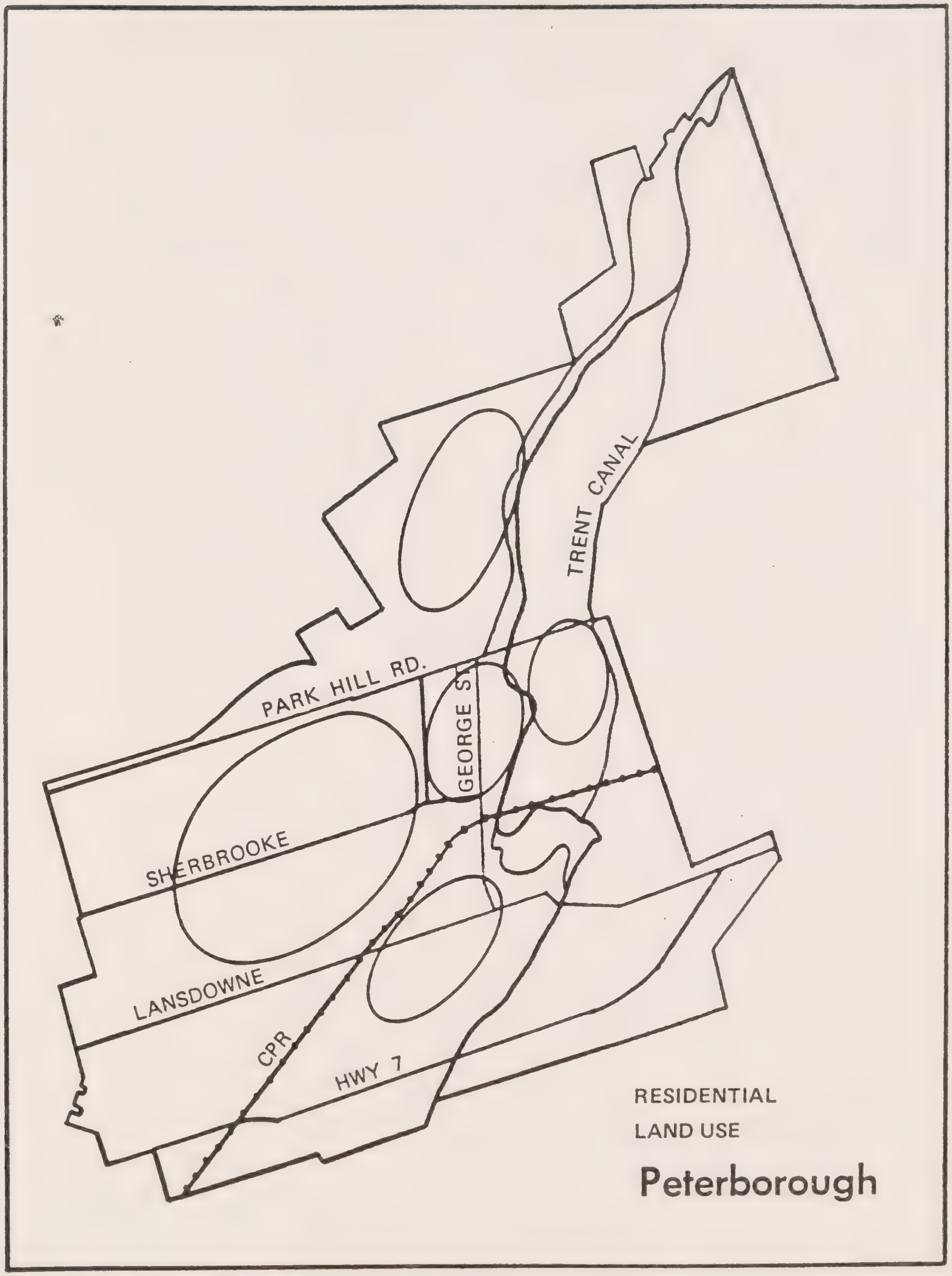
The net result of these placements left Peterborough in a relatively energy inefficient area of the matrix, as shown in Figure 5.

The intensity/distribution matrix provides an indicator of the position of the community with respect to energy efficiency. In order to determine appropriate potential strategies for each community to shift toward a more energy efficient position on the matrix, it is necessary to quantify in more depth the relationships between land use and energy consumption. Impacts on energy consumption of changes in intensity and/or distribution could then be measured and appropriate strategies devised. This process, a key for communities interested in an energy efficiency approach to planning and development, is described below.

3.2 Development of Land Use/Energy Profile

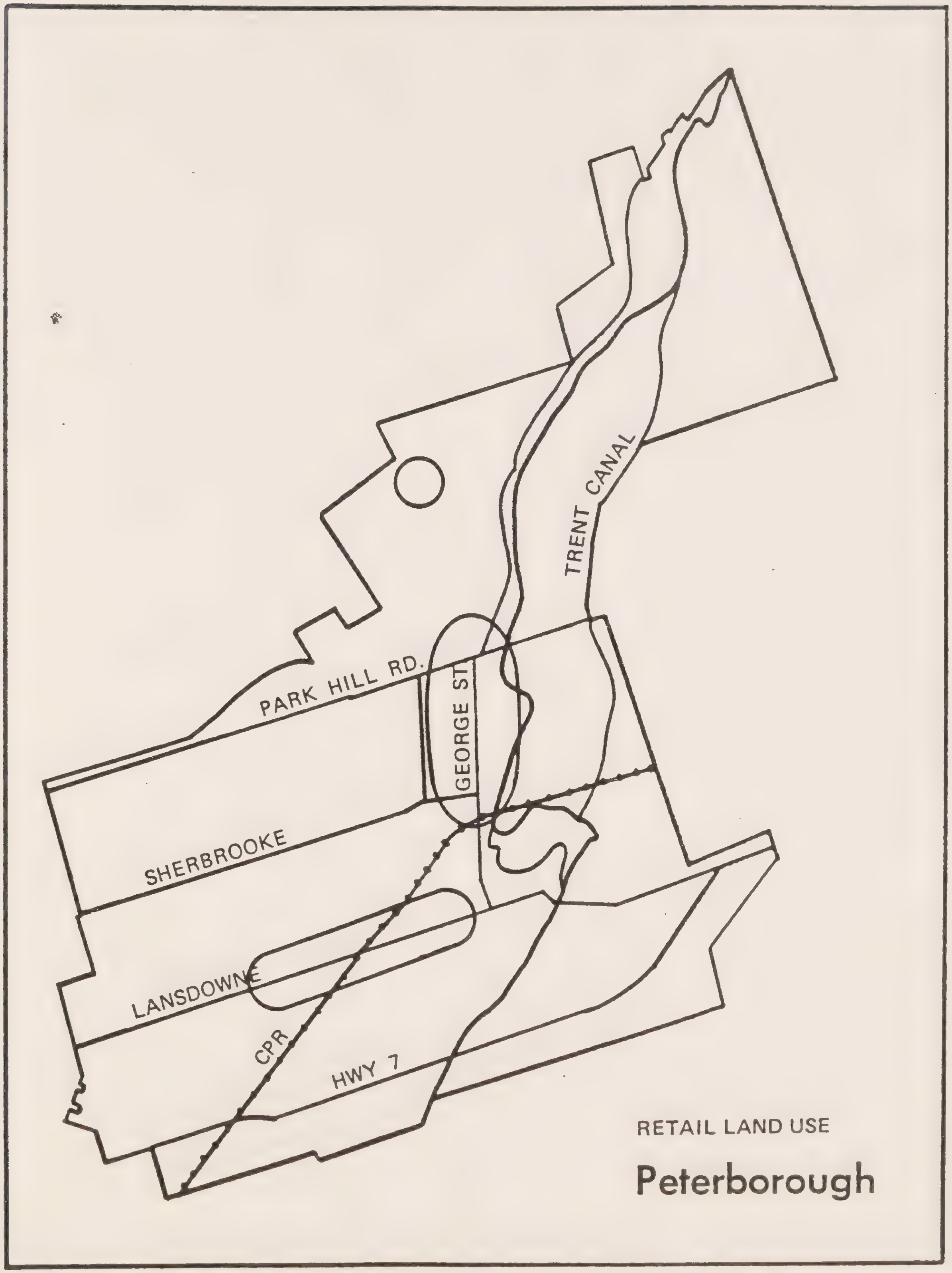
Strategies for moving to a more energy efficient position on the matrix must be based on a thorough understanding of the relationships between land use and energy consumption in any community and the trade-offs involved in terms of other planning concerns and priorities. The ability to examine energy impacts of changes or

FIGURE 4(a)



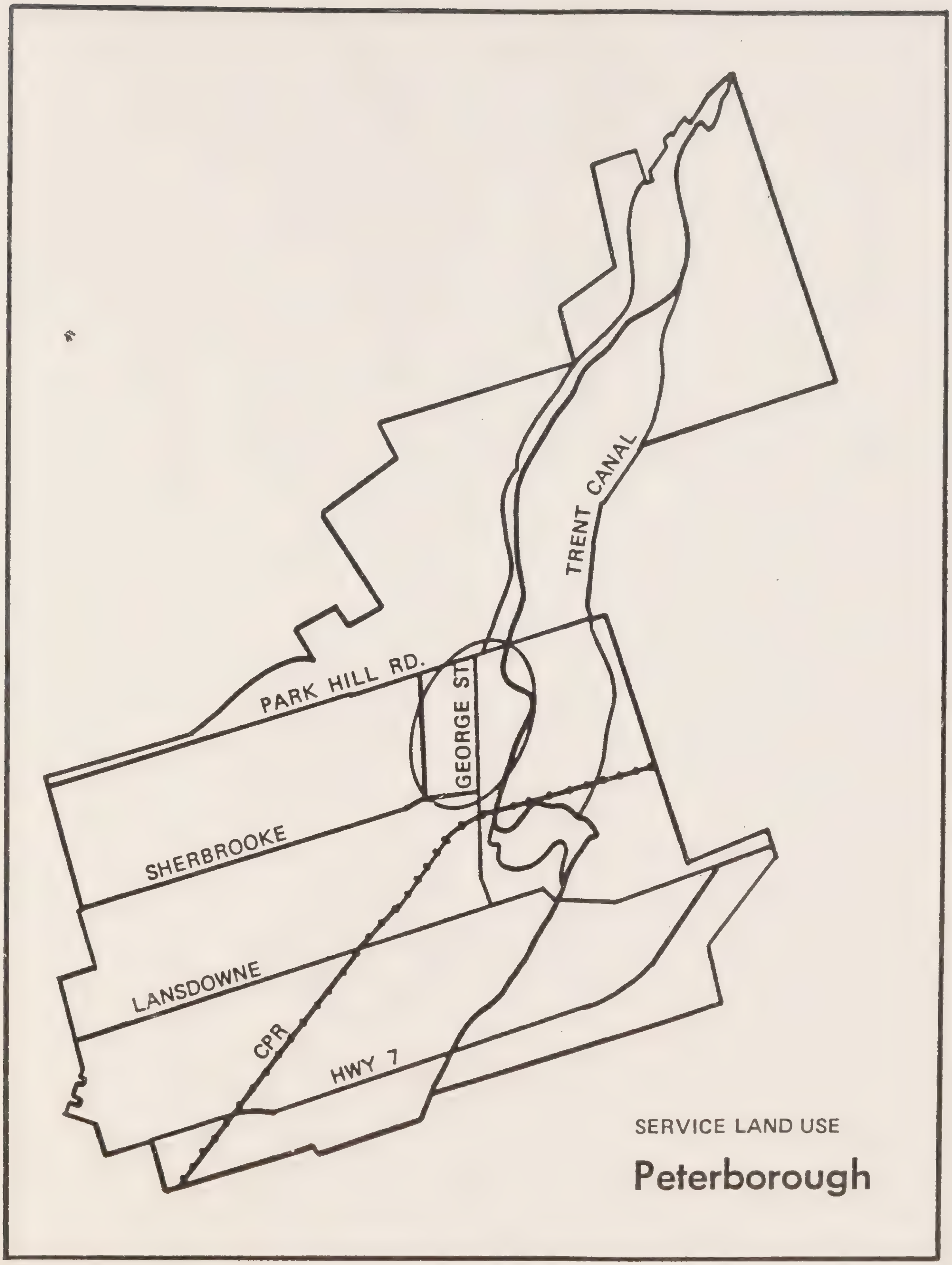
SOURCE: Woods Gordon, Enerplan

FIGURE 4(b)



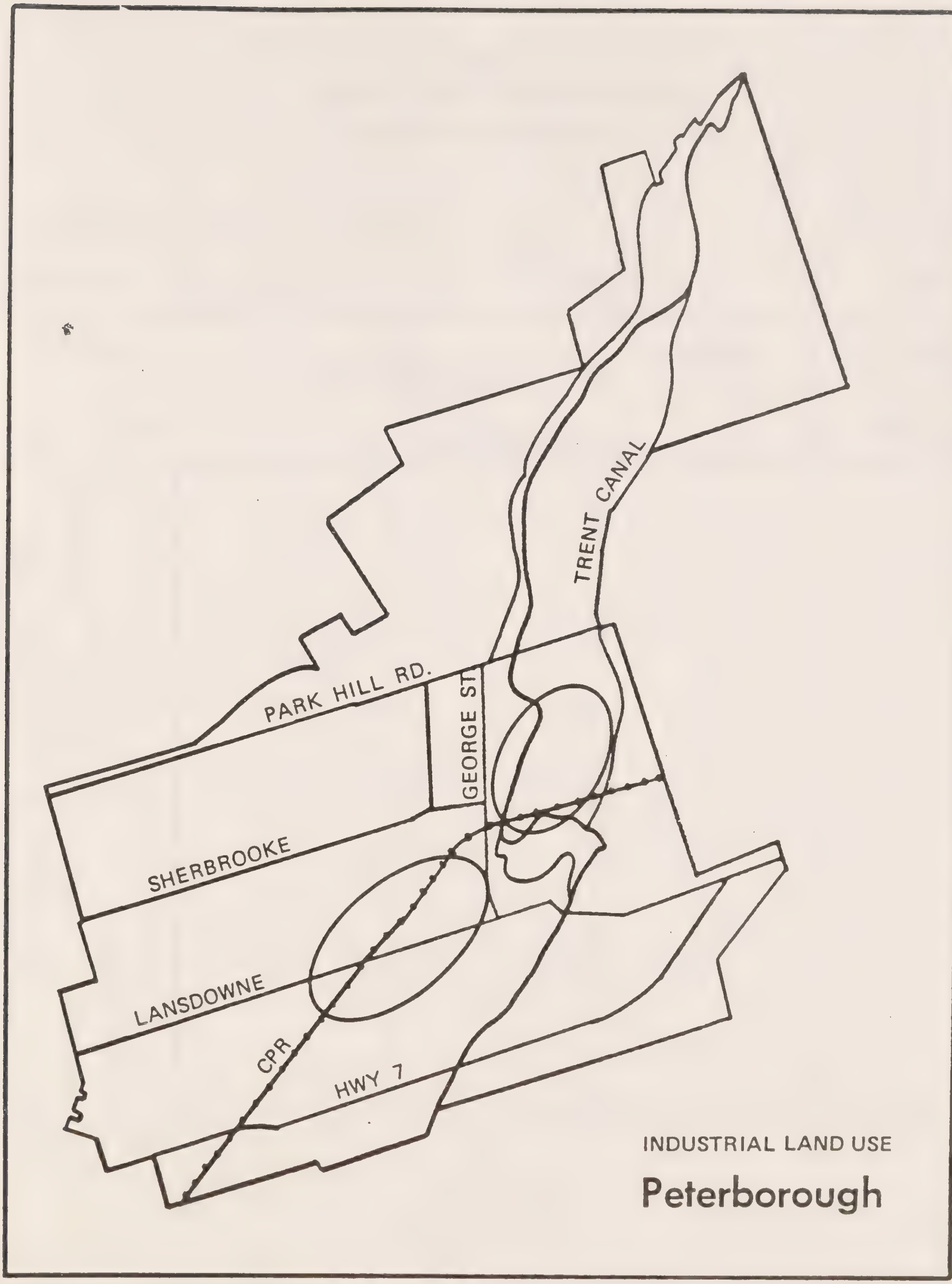
SOURCE: Woods Gordon, Enerplan

FIGURE 4(c)



SOURCE: Woods Gordon, Enerplan

FIGURE 4(d)

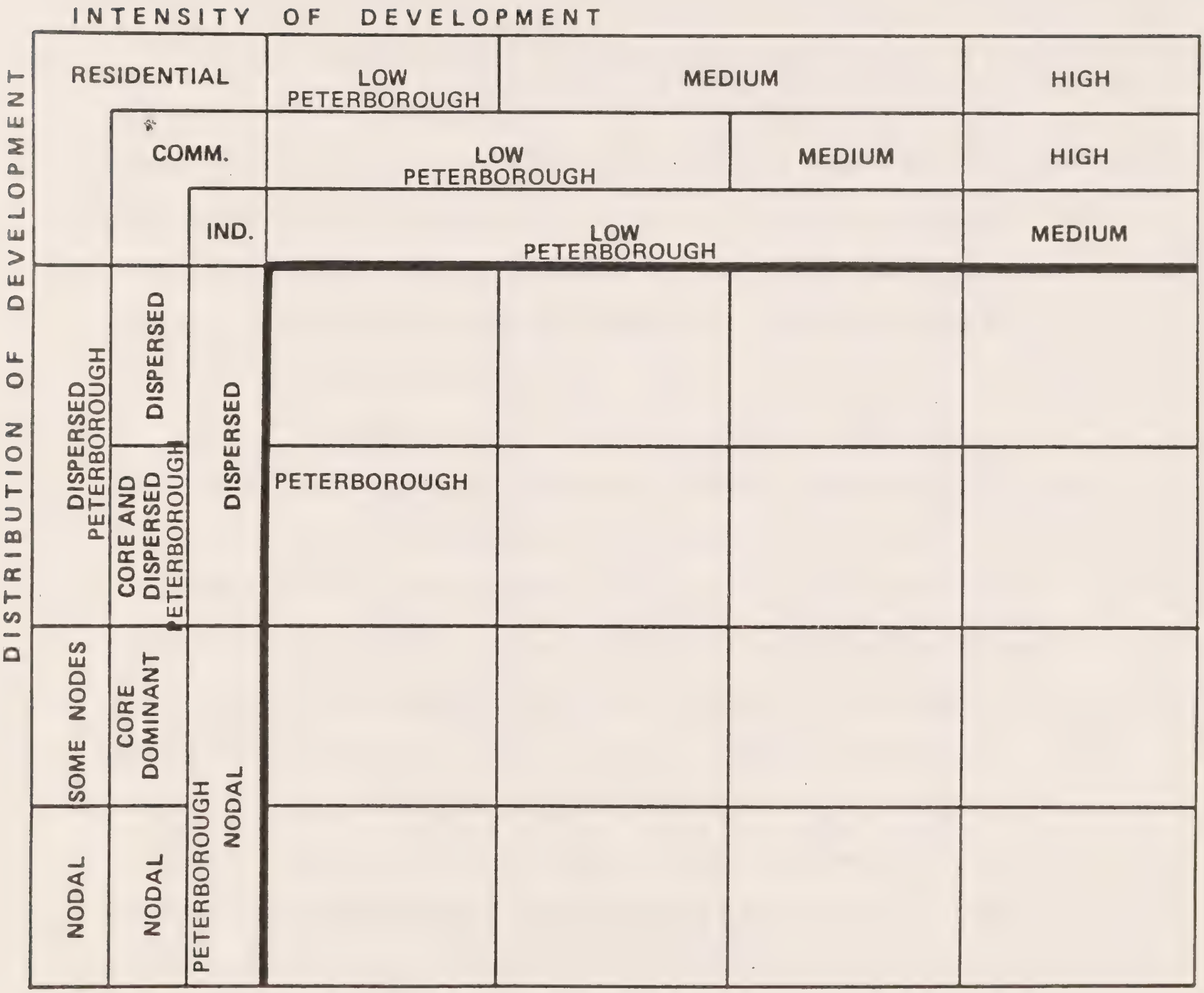


SOURCE: Woods Gordon, Enerplan

FIGURE 5

INTENSITY/DISTRIBUTION MATRIX

Placement of Peterborough



SOURCE: Woods Gordon

consumption in any community and the trade-offs involved in terms of other planning concerns and priorities. The ability to examine energy impacts of changes or proposed changes in land use intensity and distribution is essential to evaluate strategies for improving energy efficiency.

The measurement of these relationships results in the identification of a land use/energy profile for the community. It is essential that this profile be developed through readily available data in a manner easily understood and carried out by planners throughout the Province. The capability to monitor change over time must be available as well. This report sketches the framework or general approach for measuring these relationships.

Considerable work has been carried out in Ontario on the development of techniques for identifying community energy profiles. In much of this work, time-consuming collection of actual energy consumption data by sector has been the method employed. Difficulties in availability of records, analysis of raw data, availability of staff time and budget and securing co-operation and approval from appropriate agencies have contributed in many cases to a research process well beyond the scope of many planning departments. Our objective was to develop a technique which could be much easier to implement, less costly and less time consuming for community planners to develop, yet still yielding the level of detail and accuracy required to support long-term planning efforts.

Over the course of this Study, a methodology of this nature was developed and tested in our case study communities. This methodology provides the framework for quantifying land use/energy relationships and consists of:

1. identifying key land use variables impacting on energy consumption within the community;
2. determining current values for these variables in the community;
3. projecting future change in these variables, 1981-2001.

These variables then became the basis for testing the energy impacts of potential planning strategies. An emphasis on using simple measures developed from readily available data was maintained throughout this stage of the Study.

The variables selected for this purpose were organized into two tables - one for intensity of land use (which pertained primarily to space heating/cooling energy) and one for distribution of land use (which pertained primarily to transportation energy). These are noted below:

SECTOR	VARIABLE	BASE DATA
	Intensity of Land Use	
Residential	Dwelling Units	Single Semi Row Apartment
Commercial	Floorspace	Service Retail
Industrial	Employment	Light Industry Medium Industry Heavy Industry
	Distribution of Land Use	
Transportation	Number of Work Trips Average Trip Length Average Speed Vehicle Fuel Efficiency	

These variables can be translated simply into energy measures through the application of consumption indices for each. Research was carried out during the Study to identify appropriate consumption indices for each variable. It was found that work has been

FIGURE 6

INTENSITY OF LAND USE

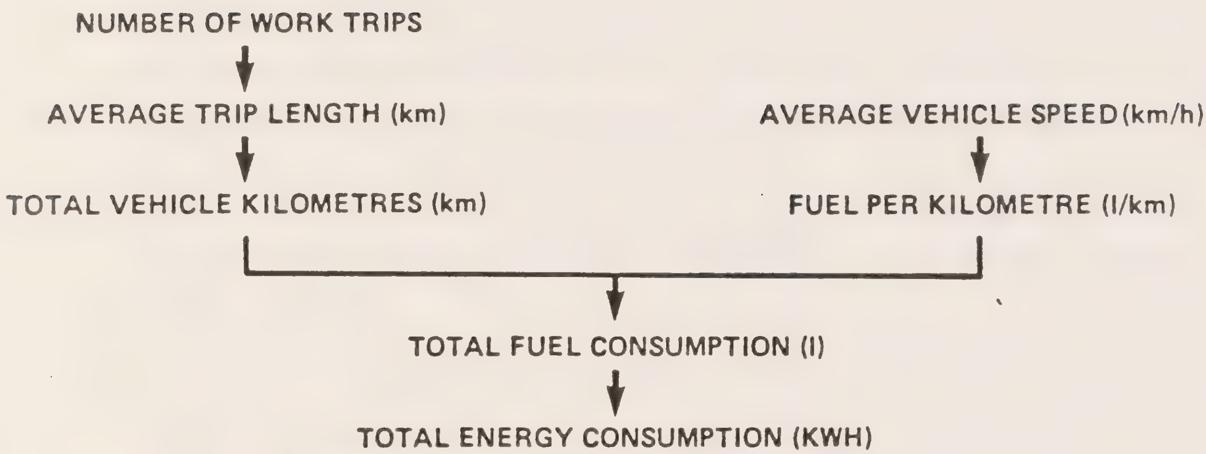
METHODOLOGY FOR CALCULATION OF ENERGY USE

SECTOR	BASE DATA		ENERGY INDICES		ENERGY (KWH)
RESIDENTIAL	UNITS • BY TYPE	x		=	
RETAIL	FLOOR SPACE • BY BUILDING TYPE	x		=	
SERVICE	EMPLOYMENT	x		=	
INDUSTRIAL	EMPLOYMENT • BY INDUSTRY TYPE	x		=	

FIGURE 7

DISTRIBUTION OF LAND USE

METHODOLOGY FOR CALCULATION OF ENERGY USE



done in this regard by agencies such as Ontario Hydro and the Ministry of Energy. With some modest refinements (e.g. to adjust for local climate), this work yielded indices for application in our Study.[1]

A more detailed description of the variables used and indices applied is provided in the Technical Appendix. Limited testing was carried out by comparing the results obtained from the method outlined in this study with results obtained from analysis of raw data gathered during the Study. This testing showed comparable findings from the two sources. As with the intensity/distribution matrix, further research in the area of consumption indices by land use would be valuable. Energy consumption indices have strong applicability throughout the Province to facilitate the development of community energy profiles, which are useful in a variety of planning applications. Figures 6 and 7 indicate the calculations used in determining community energy profiles.

The profiles developed for each case study community through application of this methodology are illustrated below. Greater detail is provided in the Technical Appendix.

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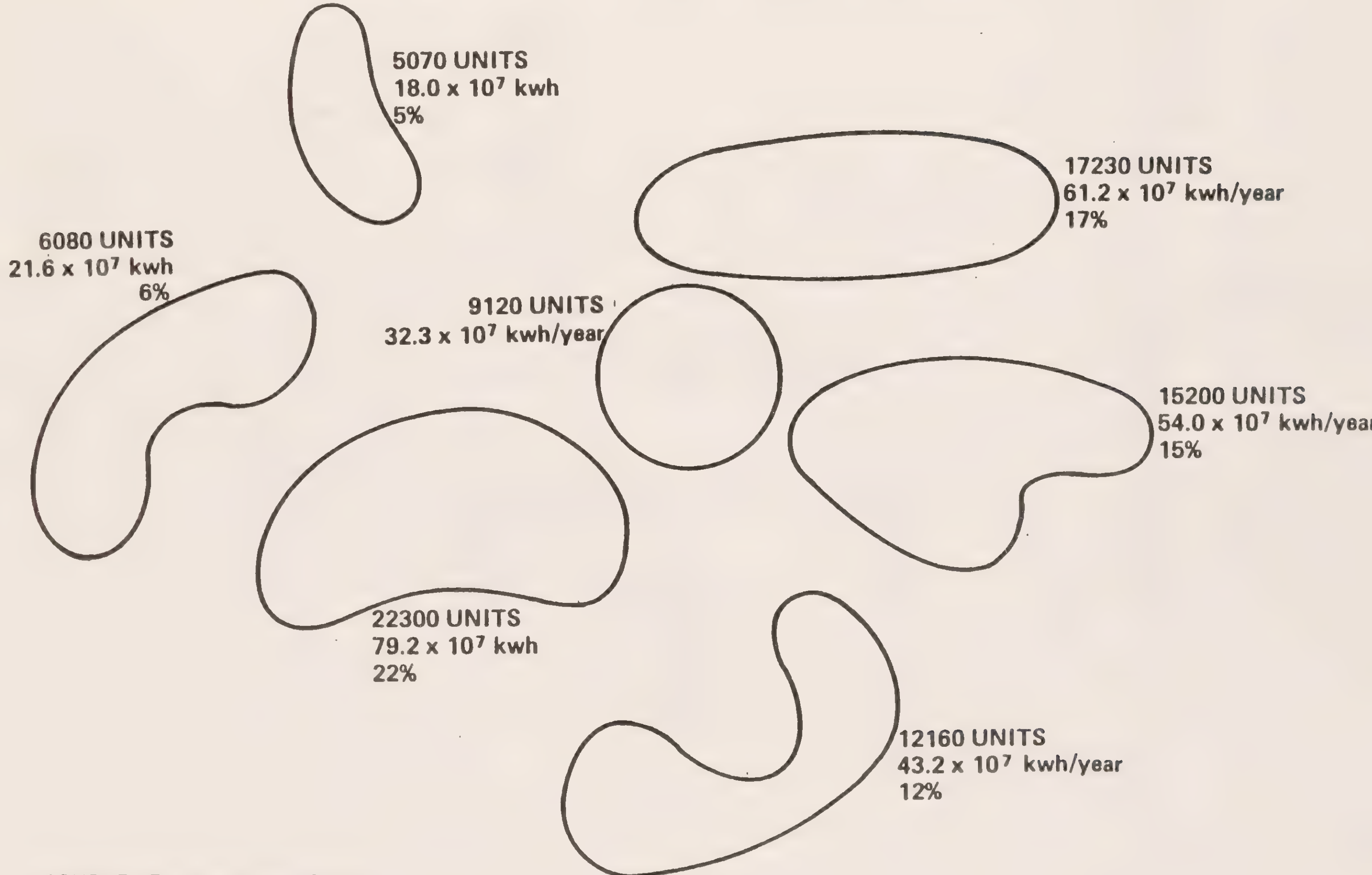
1. Throughout this study energy consumption will be measured in terms of kilowatt hours of energy per specified time period, usually one year. Kilowatt hours is only one of several possible energy measures such as joules or BTU's. Kilowatt hours may be expressed in these other measures by using a conversion factor. A table of conversion factors is found at the end of the technical appendix. The actual numbers which result are quite large and so will be expressed in scientific notation, that is in powers of ten. For example, Figure 11 shows the current level of transportation energy in London as 76.3 KWH x 10^7. When written out in full this is 763,000,000 kilowatt hours per year.

FIGURE 9

CITY OF LONDON

RESIDENTIAL ENERGY USE

1981 – 101365 UNITS
– TOTAL ANNUAL ENERGY CONSUMPTION = 359.7 x 10^7 kwh
– AVERAGE CONSUMPTION PER UNIT PER YEAR = 35500 kwh



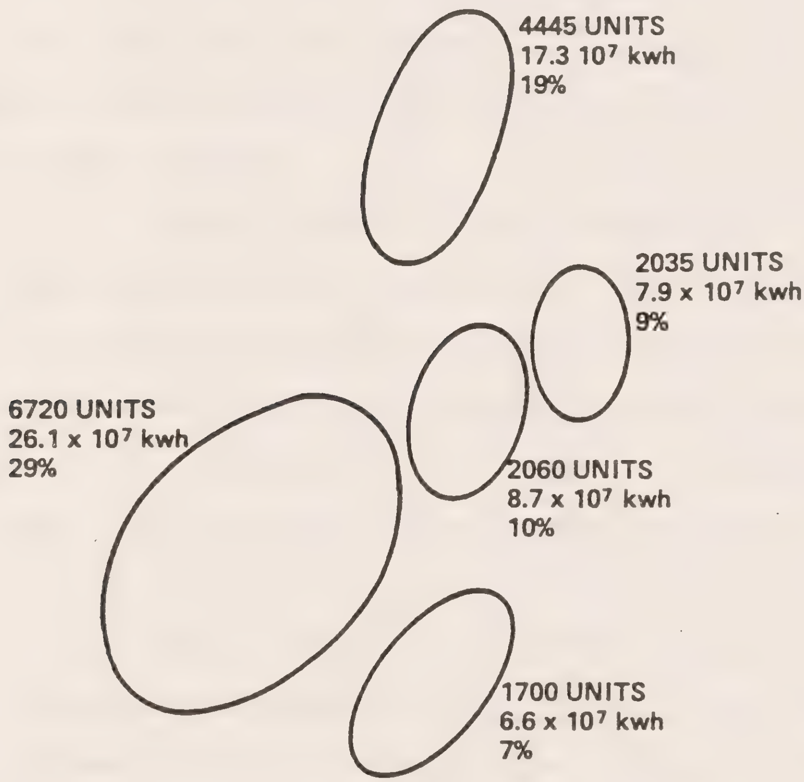
SOURCE: Enerplan, Woods Gordon

FIGURE 10

CITY OF PETERBOROUGH

RESIDENTIAL ENERGY USE

1981 – 23145 UNITS
– TOTAL ANNUAL ENERGY CONSUMPTION = 90.0 x 10^7 kwh
– AVERAGE ANNUAL ENERGY CONSUMPTION PER DWELLING = 38900 kwh



SOURCE: Enerplan, Woods Gordon

As noted above, measures of energy consumption related to intensity are a function of residential, commercial and industrial land use. For illustrative purposes, we provide below a description of residential consumption in London and Peterborough, as determined through the methodology developed in this study. Similarly, we provide our calculations on energy consumption related to distribution of land use (transportation energy) in each community. A summary table is then provided.

Figures 9 and 10 illustrate the patterns of residential energy use and the total energy consumed for residential heating and cooling in London and Peterborough, respectively. As can be seen, the patterns differ noticeably.

In London, residential energy consumption is distributed fairly evenly among five major concentrations. Little consumption occurs in the Core or the newly-developing western suburbs. In Peterborough, residential energy consumption is highly concentrated in the north and the southwest of the city. Very little consumption occurs in the Core. Similar patterns can be developed for commercial and industrial uses.

Figure 11 provides the calculations of transportation energy consumed in each community for the journey to work. This Figure points out some of the key differences between consumption patterns in cities of differing size. While London has five times the number of work trips as Peterborough, its greater average trip length results in transportation energy consumption more than nine times that of Peterborough.

FIGURE 11

DISTRIBUTION OF LAND USE

CURRENT TRANSPORTATION ENERGY
CONSUMPTION, CASE STUDY COMMUNITIES

	LONDON	PETERBOROUGH
WORK TRIPS (1980)	210,000	42,000
TRIP LENGTH (KM)	8.7	4.9
AVERAGE SPEED (KM/H)	30.0	30.0
FUEL USED PER YEAR ($KWH \times 10^7$)	76.3	8.6

SOURCE: Woods Gordon, Enerplan

FIGURE 12

CURRENT ENERGY PROFILES,
CASE STUDY COMMUNITIES, 1981
(KWH x 10^7)

		LONDON		PETERBOROUGH	
	RESIDENTIAL	359.7	33%	90.0	40%
	RETAIL	50.7	5%	12.2	5%
INTENSITY	SERVICE	215.6	20%	32.5	15%
	INDUSTRIAL	399.4	36%	79.1	36%
DISTRIBUTION	TRANSPORTATION (WORK TRIPS)	76.4	7%	8.6	4%
	TOTAL	1,101.8	100%	222.4	100%

SOURCE: Woods Gordon, Enerplan

Figure 12 points up the differences in the energy profile of each community. In both communities, residential energy is a major consumer accounting for 40% of Peterborough's energy use and 33% of London's. Commercial and retail accounts for a relatively minor proportion of total consumption. Industrial consumption comprises an equal proportion of the total in Peterborough and in London. In London however, energy consumed in the service sector represents a much higher component of total energy consumption than in Peterborugh. The differences in distribution of energy consumption demonstrate the differing economic base in each community.[1]

Transportation energy, which for the purposes of this study represent simply energy consumed in work trips, comprises a relatively modest component of energy consumption in each City. Further research beyond the scope of this Study would be required to refine further the expenditures of transportation energy in any community (eg. leisure trips, industrial shipping, etc.). Generally, however, work trips comprise by far the bulk of transportation energy consumed within urban areas. Again, the heavier transportation energy requirements of the larger community are demonstrated.

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[1] Industrial energy in this Figure includes "process" energy service. This is not distinguished from heating and cooling energy in many industries and represents a major component of energy use in many communities. The energy consequences of a municipal economic policy favouring heavy industry are clear from a chart such as this.

3.3 BASE CASE PROJECTION

The energy profile information, while developed on the basis of easily available data and relatively simple quantification techniques, can be used effectively to determine energy impacts of current long range planning policies in a given community. This can be labelled the "base case" projection.

To determine the base case projection, a number of assumptions were made in each community for each type of energy/land use relationship:

ASSUMPTIONS

Intensity of Land Use

- o Energy use depends on projected levels of activity and the energy use index of each sector
- o Projected activity is estimated by official plan designation and policies
- o Projected activity is based on a continuation of current and anticipated economic trends (eg. service sector employment growing faster than manufacturing)
- o Energy consumption indices are modified slightly to account for changes in activity by type (eg. residential units by type and age, industrial employment by type of industry).

Distribution of Land Use

- o Work trips increase directly in proportion with employment increase
- o Trip length grows by 15% between 1980 and 2001 (based on recent trends and future expectations)
- o Average speed is held constant[1]
- o Vehicle fuel efficiency is held constant[1]

These assumptions were applied to the appropriate variables in order to determine 2001 projections. The results were then

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[1] As noted earlier, technological change was held constant, as it is outside the scope of this Study.

FIGURE 13

PROJECTED ENERGY PROFILES,
CASE STUDY COMMUNITIES, 2001
(KWH x 10^7)

		LONDON		PETERBOROUGH	
	RESIDENTIAL	458.4	30%	114.0	40%
	RETAIL	57.9	4%	14.5	5%
INTENSITY	SERVICE	344.3	22%	38.0	13%
	INDUSTRIAL	564.4	37%	105.5	37%
DISTRIBUTION	TRANSPORTATION (WORK TRIPS)	118.9	8%	11.4	4%
	TOTAL	1,543.9	100%	283.4	100%

SOURCE: Woods Gordon, Enerplan

FIGURE 14

PROJECTED ENERGY PROFILE, LONDON

% CHANGE

IN ENERGY CONSUMPTION 1981 - 2001

		ACTIVITY	ENERGY USE	
			Trend Scenario	Low Energy Scenario
	RESIDENTIAL	28%	27%	25%
INTENSITY	RETAIL	18%	14%	14%
	SERVICE	60%	60%	54%
	INDUSTRIAL	50%	41%	32%
DISTRIBUTION	TRANSPORTATION (WORK TRIPS)	36%	56%	42%
	TOTAL			

SOURCE: Woods Gordon, Enerplan

FIGURE 15

PROJECTED ENERGY PROFILE, PETERBOROUGH

% CHANGE

IN ENERGY CONSUMPTION 1981 - 2001

		ACTIVITY	ENERGY USE	
			Trend Scenario	Low Energy Scenario
INTENSITY	RESIDENTIAL	25%	27%	22%
	RETAIL	21%	19%	19%
	SERVICE	17%	17%	15%
	INDUSTRIAL	33%	33%	27%
DISTRIBUTION	TRANSPORTATION (WORK TRIPS)	15%	33%	21%
	TOTAL			

SOURCE: Woods Gordon, Enerplan

distributed according to official plan policies on housing mix, density, commercial and industrial designations, etc. Energy consumption indices were applied and the results analyzed.

Figure 13 summarizes the energy impacts of accommodating projected growth according to present official plan policies. In both communities, such policies emphasized many of the more traditional planning and development approaches, such as continued suburbanization of residential growth and movement of industry from the central city to the outer fringes.

Comparison with Figure 12 demonstrates the results of this process. Total energy consumption rises 40% in London and 27% in Peterborough. In London the proportion of total energy consumed drops in the residential, retail and transportation sectors, rises in the service sector and remains constant in the industrial sector. Peterborough's proportional consumption increases in the industrial sector, decreases in the service sector and remains the same in residential, retail and transportation.

Figures 14 and 15 provide further comparisons by showing percent change in consumption by sector. Because of factors such as increased energy efficiency in newer development,[1] the percentage increase in energy use for various activities is less than the increase in developed space. Transportation energy use, however, rises faster than the increase in work trips in both communities. This is because Official Plan policies which spread development outward at relatively low density result in increased travel times and distances, thereby raising transportation energy consumption.

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[1] New development is more energy efficient on average than existing development due to new energy supply technologies (e.g. heat pumps) and stricter building code standards (e.g. insulation).

Policies which would redistribute such activities in a more energy efficient manner clearly would have a considerable desirable impact on transportation energy consumption.[1]

Further refinement of the transportation results could be achieved through development of a simple gravity model of transportation flows. This model would allocate work trips between residences and places of employment. The trips could then be translated into energy consumption totals. Development of such a model subsequent to this Study would be a most useful step in further developing this methodology.

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1 It should be emphasized that policies which affect transportation energy are very important due to the multiplier effect between number of trips and trip length and the effect this has on the level of transportation energy consumption. Figures 14 and 15 demonstrate this. For example, a 36% increase in trips in London results in a 56% increase in energy used. This is due to the increase in trip length assumed for the trend scenario. A similar effect can be seen in Peterborough.

4. DEVELOPING A REALISTIC 2001 SCENARIO

4.1 Introduction

The preceding results point out the levels of energy consumption resulting from pursuing present Official Plan development policies. In order to determine a more energy efficient approach to development it is necessary to identify potential planning measures which would place the community in a stronger position on the intensity/distribution matrix. These measures must then be evaluated in terms of their practicality and feasibility for implementation in the community. When a set of appropriate measures is determined, a planning and development scenario can be devised and energy impact gauged and evaluated against other planning goals and priorities.

These steps are carried out below.

4.2 Testing the Approach

Applying the analysis developed earlier yields a host of potential measures which can be adopted to determine an energy efficient approach to planning and development. Yet, planners must ensure that these measures are feasible as energy saving approaches and practical to implement in a given community. Many studies have been carried out to identify energy efficient planning techniques; few have provided methods for determining their practicality and feasibility.

This Study has been carried out with implementation as an uppermost concern. Clearly, the ideas and approaches put forward in this Report will be of little value if community planners across Ontario are uncertain of their applicability. This is the point at which much of the past research work in energy efficient land use planning has fallen short.

For this reason, a simple methodology was developed over the course of the Study to test the feasibility and practicality of approaches which might be considered to improve the long-run energy efficiency of community development patterns. This methodology is noted briefly below. A more detailed description is provided in the Technical Appendix.

The methodology devised for testing the approach consists of four steps:

- o Identifying potential energy conservation approaches
- o Identifying evaluation criteria to judge practicality
- o Preparing an evaluation matrix to apply criteria to each conservation approach
- o Application of the evaluation matrix to select those conservation approaches which rank as being most practical.

Completion of the fourth step will provide the combination of most practical approaches from which an energy efficient community development scenario can be drawn.

The following outlines the results of this methodology as applied in our case study communities.

The initial step in each case was an identification of potential energy approaches. Lists were developed, keeping in mind the position on the intensity/distribution matrix of each community and the results of the energy profile analysis to ensure that the measures proposed werw appropriate and applicable to the community. Approaches were identified through literature review, interviews with planners and energy experts and discussions within the Project Team. All approaches identified were considered to be currently available to community planners in Ontario. The list, of course, can be amended or expanded to suit a particular municipality.

Approaches were categorized according to whether they were primarily related to intensity of land use or distribution of land use. Examples included:

<u>Intensity of Land Use</u>

- o Encourage higher densities
- o Encourage infill development
- o Minimize highway strip development

<u>Distribution of Land Use</u>

- o Encourage mixed-use development
- o Encourage self-contained neighbourhoods
- o Develop transit corridors

At the same time, evaluation criteria were developed; again through literature review, interviews and Project Team discussion. Particular care was taken to standardize the results to facilitate evaluation and comparison. This was achieved through:

- o precise wording of criteria
- o formulation of an example or "typical" case community to provoke discussion of specific/local conditions
- o working with a large number of specific criteria
- o ensuring the criteria were comprehensive
- o including a "not applicable" category as part of the scoring process
- o basing the result on a relative ranking of approaches, not the absolute score

Criteria were grouped into several categores. Categories used and examples of criteria are noted below (see Technical Appendix for detailed listing):

Demographic

- o population size
- o household size
- o age distribution

Physical

- o concentration of development
- o existing building conditions
- o capacity and condition of existing hard services

Economic

- o employment base and trends
- o housing market
- o energy prices

Social

- o acceptance of mixed use development
- o household energy consumption behaviour

Institutional and Legal

- o Government incentives

Upon identifying potential conservation approaches and evaluation criteria, an evaluation matrix was drawn up to develop scoring and ranking results. Figure 16 presents a simplified outline of the matrix.

The Project Team then scored each identified approach according to the evaluation criteria. A community with an aging population, declining household size and rising proportion of non-family households, for example, scored strongly in terms of demographic criteria for raising residential densities.

A simple system of; plus, minus, zero or not applicable facilitated scoring. The process was carried out on a rather general level, using the concensus judgement of members of the Project Team. Communities adopting this process might wish to be more rigorous in their scoring,

based on more intimate knowledge of local conditions. We found, however, that the results obtained were quite adequate for the purpose of the exercise.

The evaluation matrix was found to yield a number of important benefits to any municipality considering adopting an energy efficient approach to community development patterns. Because of the comprehensive nature of the matrix, there is little probability of excluding any practical approach. The matrix structure promotes easier understanding and use of the practicality evaluation process; also, it makes comparison between and among potential approaches relatively easy. The structured approach improves the consistency of evaluation results. The generality of the matrix ensures the widest possible range of conservation approaches can be evaluated, thereby allowing the evaluation process to be more widely used. We found that, overall, the matrix encourages the developing of an understanding of energy/land use relationships in the community.

The application of the evaluation matrix to London and Peterborough yielded sets of planning approaches which were practical to implement, feasible in the community and consistent with the directions indicated by the position of each on the intensity/distribution matrix (see Chapter 2). Because of the differences in the characteristics of each community, these sets of approaches differed noticeably for each community. The set of approaches finally determined as the basis for an energy-efficient approach to community planning and development in each area is as follows:

FIGURE 16

EVALUATION MATRIX

APPROACH	CRITERIA					TOTAL SCORE	RANKING
	DEMOGRAPHIC	PHYSICAL	ECONOMIC	SOCIAL	LEGAL		
INTENSITY OF LAND USE							
DISTRIBUTION OF LAND USE							

SOURCE: Woods Gordon, The Starr Group, Enerplan

LONDON

- Encourage Mixed Use Development
- Enourage the Emergence of Multi-Use Centres
- Encourage Core-Area Housing
- Raise Permitted Residential, Commercial and Industrial Densities
- Encourage Multi-Use Buildings
- Encourage the Development of Transit Corridors

PETERBOROUGH

- Encourage Core Area Housing
- Emphasize Infill Development
- Encourage Nodal Concentrations of Development
- Permit Residential Conversions

4.3 The 2001 Scenario

The final stage in the process of adopting an energy efficient approach to community planning and development is to incorporate the above ideas into the long run planning strategy of the community. This could result in a revised land use plan for the community. The energy impacts of the revised plan can be compared to the Base Case (see Chapter 3) to estimate the potential energy savings and to evaluate against other effects, options and consequences.

In many ways, the result will be not only a saving in energy consumption, but a community which is planned with greater foresight in anticipating future economic and environmental conditions. By increasing a planner's expertise in dealing with energy conservation, the planner's awareness and expertise is improved in related areas of scarce resource conservation, integrating resource and land use planning and effects of land use planning on social and economic issues. A much

stronger basis for consistent day-to day decision making regarding planning and development matters would be present. The matrix description and matrix evaluation approaches described here are generally applicable to many planning issues. The use of these methods encourages a conscious, consistent approach to planning which emphasizes structured examination and discussion of issues without being too abstract or convoluted. Planners likely would benefit from a greater understanding by the community of the rationale behind planning decisions.

The sets of conservation approaches noted above were applied to our case study communities in the year 2001. This was carried out through revising the land use variables (see Chapter 3) accordingly, quantifying the resulting energy consumption and comparing the results with the Base Case developed earlier.

The results of this process are noted in Figures 17 and 18. Figure 17 demonstrates that total energy consumption declines by an estimated 4% in each community. Transportation energy use is particularly reduced in each case, with other noticeable improvements coming in residential, some commercial activity and industrial use. Slight shifts in the distribution of energy consumption by activity are also apparent. The savings are due to the application of the conservation approaches outlined above. For example, in the case of transportation energy the reduction is due to an assumed reduction in trip lengths made possible by greater development densities and greater clustering of development.

Figure 18 translates these percentage figures into 1982 dollar terms. In London, it is estimated that the direct energy savings could total almost $25 million per year. In Peterborough, the figure is

FIGURE 17

SUMMARY OF
DIRECT ENERGY SAVINGS

ENERGY EXPRESSED AS KWH X 10^7 PER YEAR

LONDON	2001	
	TRENDS SCENARIO	CONSERVATION SCENARIO
RESIDENTIAL	458.4	448.9
RETAIL	57.9	57.9
SERVICE	344.3	331.4
INDUSTRIAL	564.4	526.4
TRANSPORTATION (Work Trips Only)	118.9	108.7
TOTAL	1,543.9	1,473.2

PETERBOROUGH	2001	
	TRENDS SCENARIO	CONSERVATION SCENARIO
RESIDENTIAL	114.0	109.8
RETAIL	14.5	14.5
SERVICE	38.0	37.5
INDUSTRIAL	105.5	100.2
TRANSPORTATION (Work Trips Only)	11.4	10.4
TOTAL	283.4	272.4

SOURCE: Woods Gordon, Enerplan

FIGURE 18

SUMMARY OF
DIRECT ENERGY SAVINGS

ENERGY EXPRESSED AS MILLIONS OF DOLLARS PER YEAR IN 1982 PRICES(1)

LONDON	2001	
	TRENDS SCENARIO	CONSERVATION SCENARIO
RESIDENTIAL	\$160.4	\$157.1
RETAIL	20.3	20.3
SERVICE	120.5	116.0
INDUSTRIAL	197.5	184.2
TRANSPORTATION (Work Trips Only)	47.6	43.5
TOTAL	\$546.3	\$521.1

PETERBOROUGH	2001	
	TRENDS SCENARIO	CONSERVATION SCENARIO
RESIDENTIAL	\$39.9	\$38.4
RETAIL	5.1	5.1
SERVICE	13.3	13.1
INDUSTRIAL	36.9	35.1
TRANSPORTATION (Work Trips Only)	4.6	4.2
TOTAL	\$99.8	\$95.9

(1) For Land Use an average cost of 3.5 cents per KWH was used. This is based on an average cost of all energy sources utilized in land uses. It includes consideration of lower rates for bulk users of electricity and natural gas. For Transportation an average cost of 4.0 cents per KWH was used. This is based on gasoline costing 39 cents per litre.

SOURCE: Woods Gordon, Enerplan

$5 million. Multiply these types of results across potentially dozens of communities over a number of years and the total energy saved in Ontario would be substantial.

These direct energy savings also can give rise to multiplier effects throughout the urban system. Reducing transportation energy consumption, for example, might reduce the energy required for road repair and maintenance. Raising densities might enhance the opportunities for district heating. Developing more compact communities might reduce the energy required to develop and operate more extensive sewer and water systems. And on and on.

As noted earlier, an understanding of any related social and economic costs and benefits of adopting energy efficient approaches to community development is important. While recognizing that, for example, research into areas such as the effects of living at higher densities and the effects of moving away from strict separation of land uses would be most useful, constraints of time and budget do not allow for such work within the scope of this Study. Exploration into such issues, however, should be carried out in further refining the planning concepts raised in this Report.

5. CONCLUSIONS: WHERE DO WE GO FROM HERE

This Study has taken a first step into the development of planning approaches consistent with the environment facing communities across Ontario over the next twenty years. As traditional planning concepts become less and less applicable to current and anticipated social and economic conditions, the need to further develop and refine new planning approaches will intensify.

This Study has demonstrated that basing an approach to community planning and development on energy efficiency holds many advantages. It is consistent with the economic realities facing our communities. It results in potentially significant savings in energy use. It leads to multiplier savings in energy consumption throughout the community. It provides a sound basis for decisions facing planners now and in the future.

The simple techniques outlined here for analysis, evaluation and planning show promise. They can be developed and applied with readily available data, refined and customized through the work of local community planners and implemented with confidence. Although very little meaningful research has been conducted into these broader approaches, the results of our Study demonstrate the potential for positive results. In short, this work is an interesting beginning which opens some doors.

But the questions which remain are many. Further research into costs and benefits (particularly social costs) is a key. Refinement of energy consumption indices and appropriate land use variables would be most useful particularly through further comparison with real consumption data. Establishing intensity/distribution

positioning for a wide range of communities in order to allow for relative positioning would be extremely helpful. The effect of urban size and form must be clarified. Refinement of transportation/land use impacts could be accomplished throughout development and testing of appropriate gravity models. Handbook materials and other information should be developed for distribution around the Province. Greater understanding of the fundamental relationships between intensity of land use, distribution of land use and energy consumption would be of tremendous value. Further innovative design work on broad urban settlement forms and energy consumption would contribute further.

It takes several years to influence development decisions to implement land use policies, and then to have new development patterns result in changes in energy consumption. This means that now is the time to start planning with energy conservation in mind. Beginning now will also give communities the opportunity to plan for future growth in anticipation of an improvement in the economy.

Planning approaches to the future development and redevelopment of communities across Ontario will continue to evolve. The ideas presented in this Study and the further areas of research and development noted above could represent an important step in this evolution. We believe efforts such as these could help many communities articulate new planning directions and strategies to address changing environments. We look forward to being part of this most interesting stage in the evolution of planning thought in Ontario.

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